(12) UK Patent Application (19) GB (11) 2 056 169 A

(21) Application No 8023045
(22) Date of filing 15 Jul 1980
(30) Priority data
(31) 54/095004
(32) 27 Jul 1979
(33) Japan (JP)
(43) Application published 11 Mar 1981
(51) INT CL³ H01L 21/64
(52) Domestic classification H1K MB
(56) Documents cited
GB 1314590
GB 1255939
GB 948450
(58) Field of search
B3B
B8A
B8T
H1K
H1M

(71) Applicants
Hitachi, Ltd., 5—1, Marunouchi 1-chome, Chiyoda-ku, Tokyo, Japan
(72) Inventors
Hiroshi Nagatomo,
Hisashi Maejima,
Jun Suzuki,
Keishin Fujikawa
(74) Agents
Mewburn Ellis & Co., 70 & 72 Chancery Lane, London, WC2A 1AD

(54) Manufacturing system for semiconductor devices

(57) In a versatile manufacturing system comprising a plurality of treatment sections and a conveyance device conveying workpieces between these sections, the arrangement of respective treatment sections 15, 17, 19, 21, 23, 25, 27 is made job-shop-type, and the construction of treating devices 14, 16, 18, 20, 22, 24, 26 included in the treatment sections is made flow-shop-type, to achieve consecutive automation. In order to make also the management of the process automated, a stocker 28 in which unfinished products are put is situated in a specified place of the system such as the central part thereof, while a conveyor machine 33 controlled by a control unit 29 having a computer reciprocates along a path 12 between the stocker and the groups of treatment sections. The manufacturing system is suitable for the fabrication of semiconductor devices.

FIG. 2

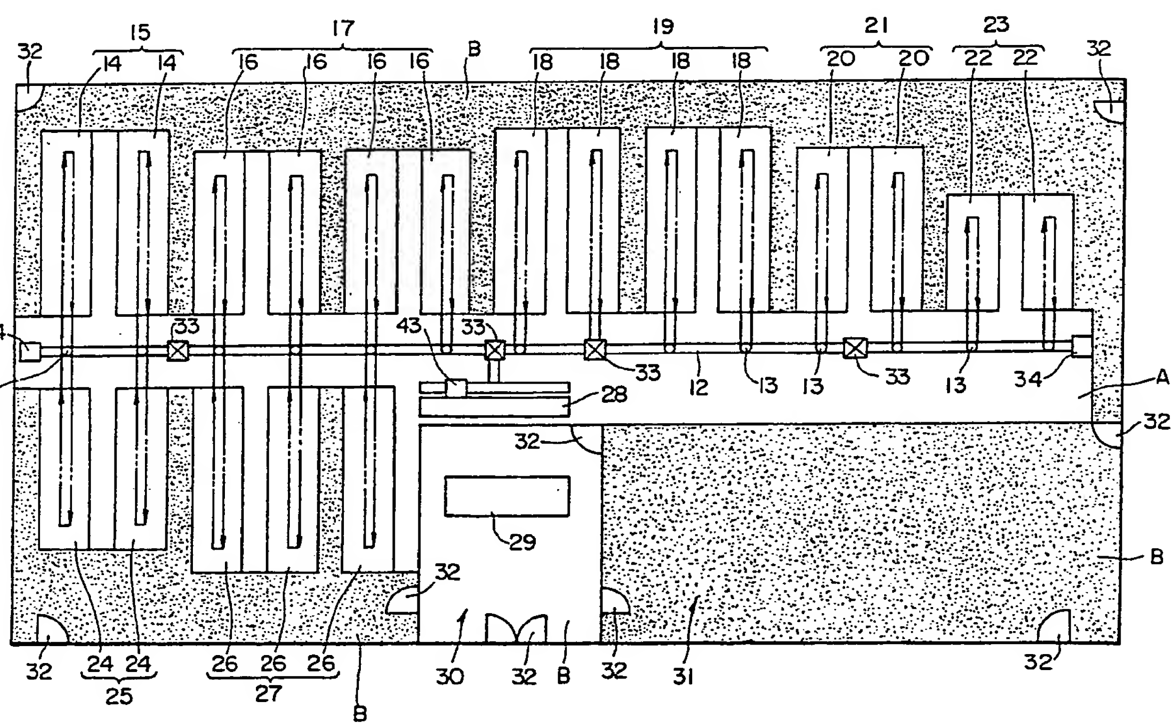

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FIG. 1

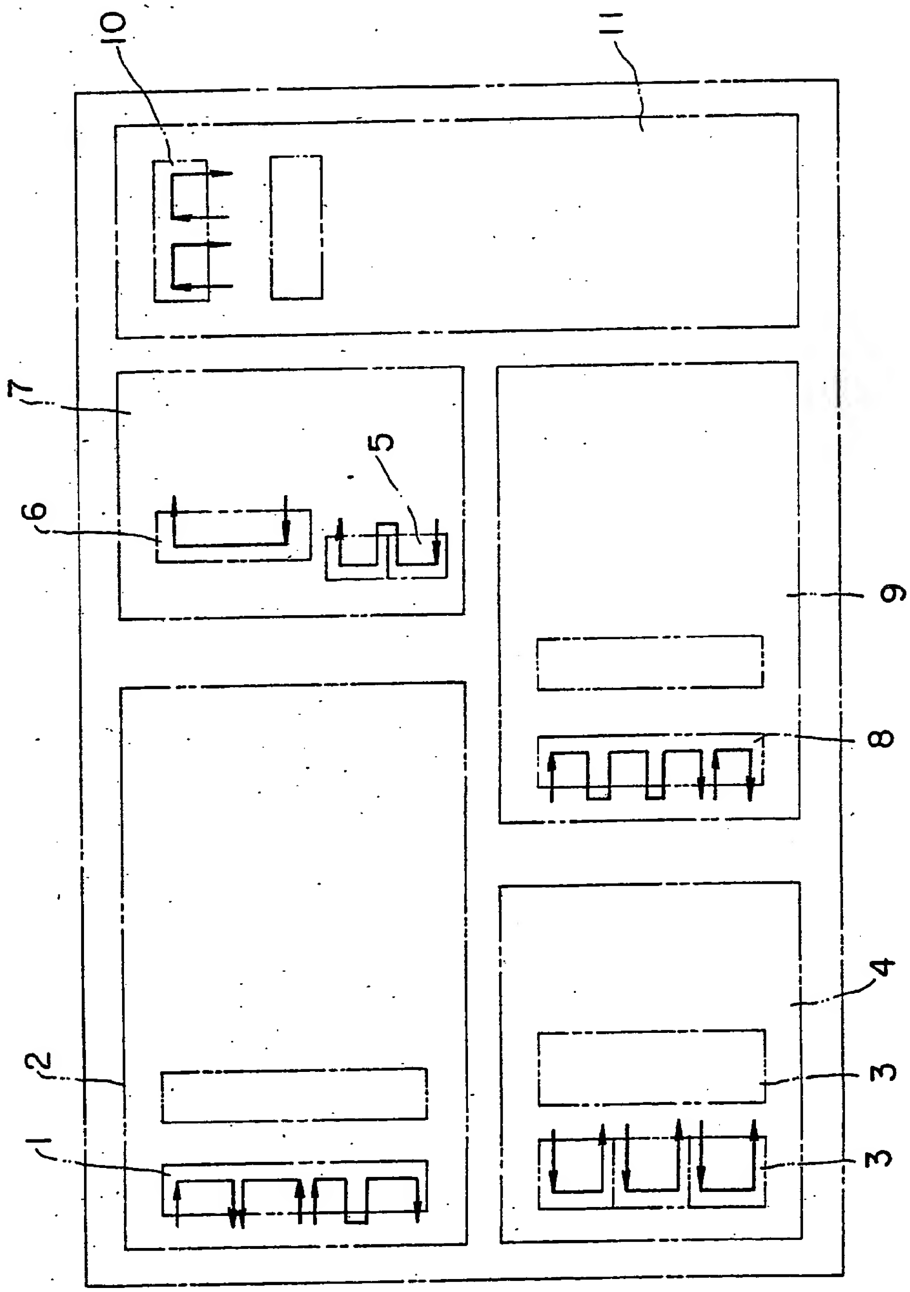

FIG. 2

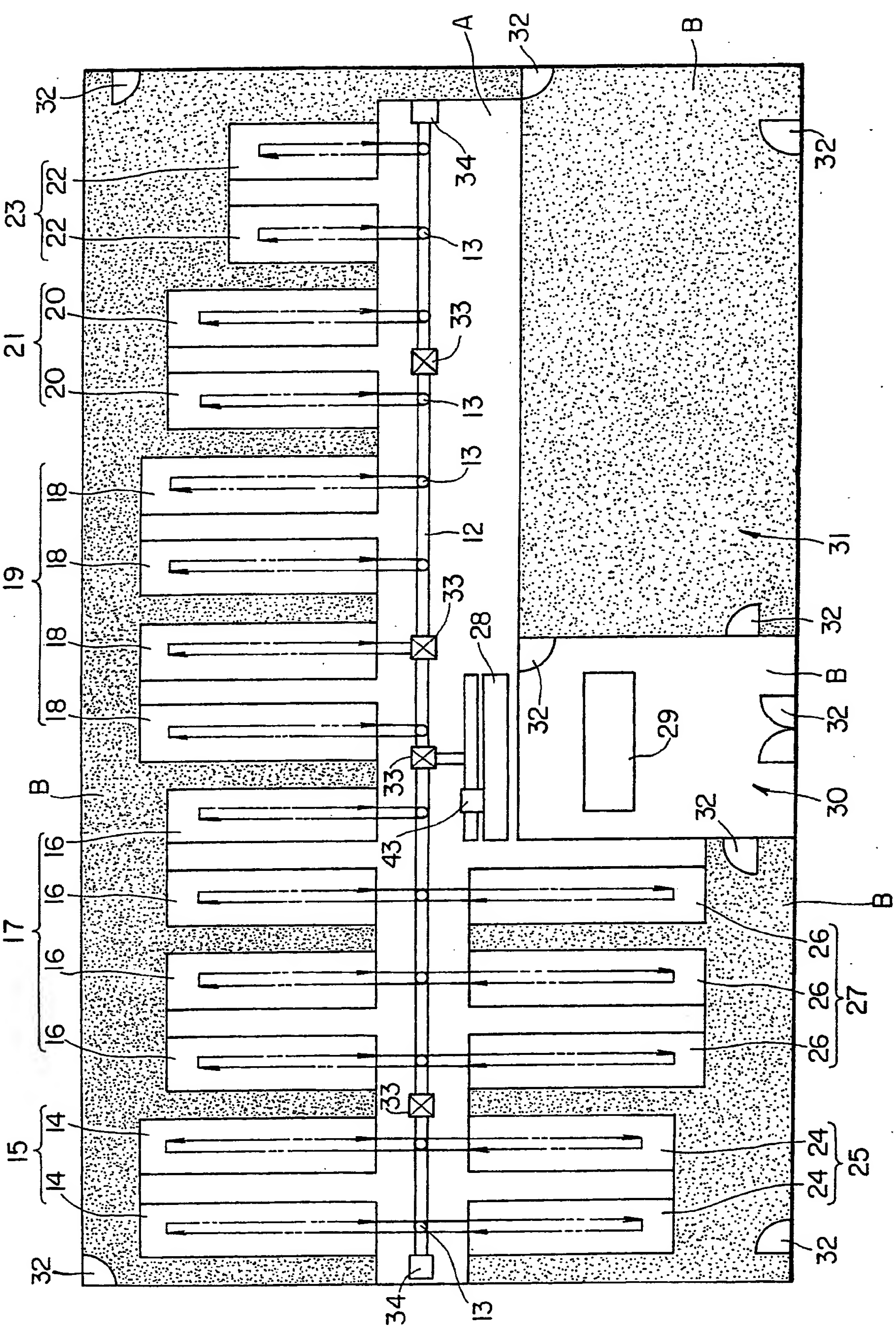
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FIG. 3

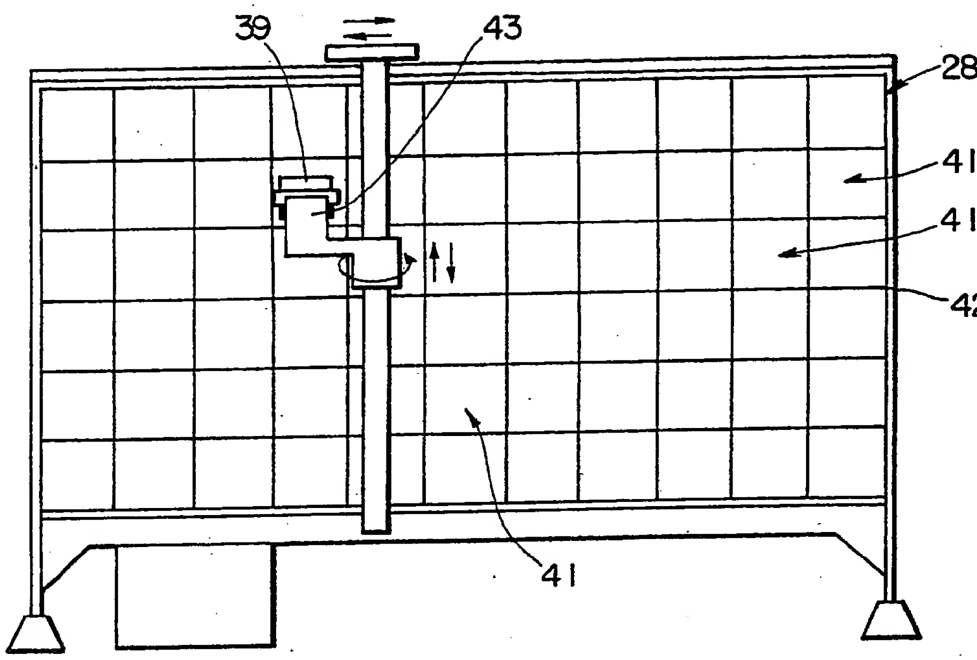


FIG. 4

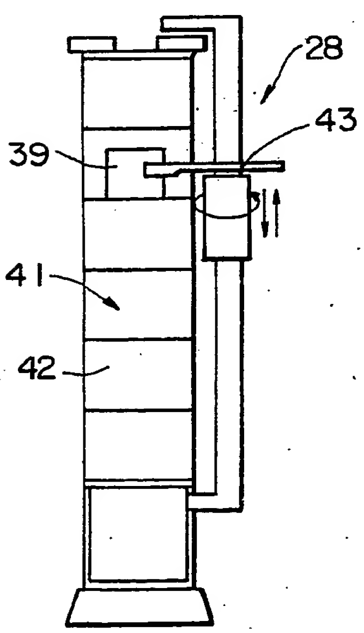


FIG. 5

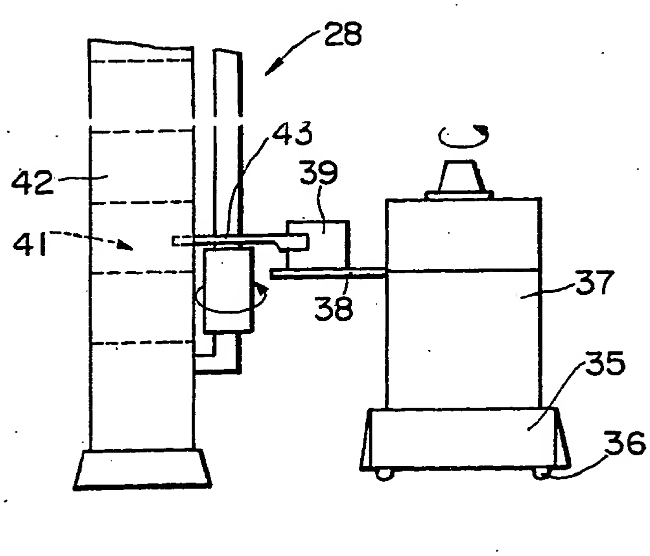


FIG. 6

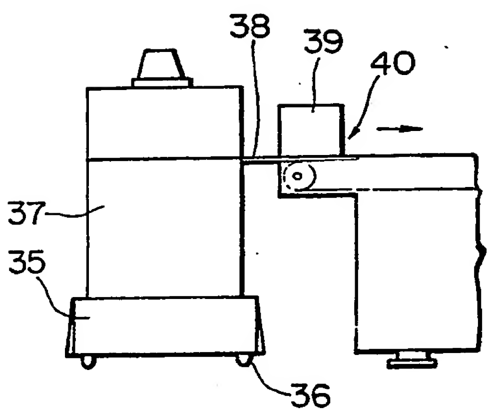


FIG. 7

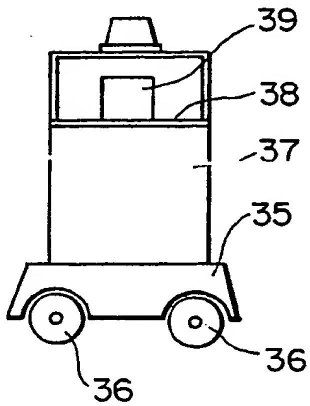


FIG. 8

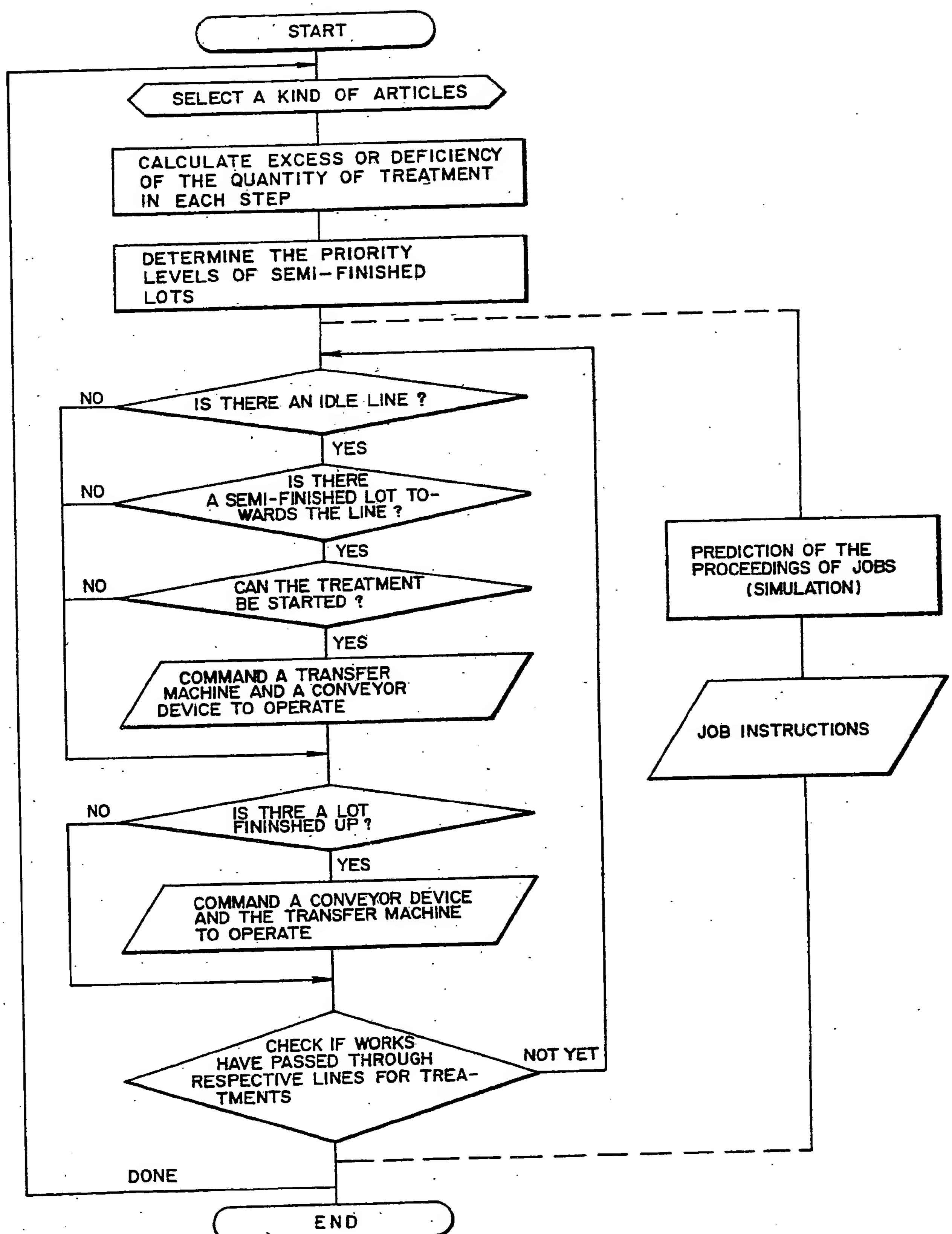
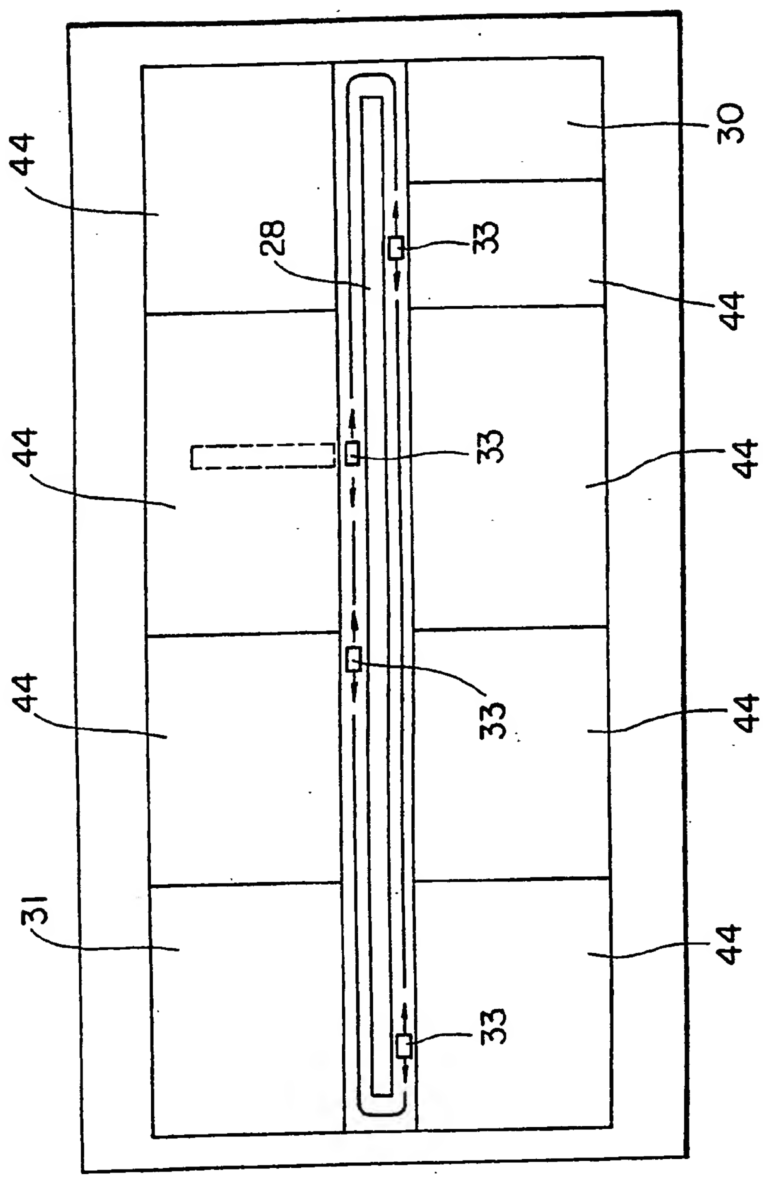

START
SELECT A KIND OF ARTICLES
CALCULATE EXCESS OR DEFICIENCY OF THE QUANTITY OF TREATMENT IN EACH STEP
DETERMINE THE PRIORITY LEVELS OF SEMI-FINISHED LOTS
IS THERE AN IDLE LINE ?
NO
YES
IS THERE A SEMI-FINISHED LOT TO-WARDS THE LINE ?
NO
YES
CAN THE TREATMENT BE STARTED ?
NO
YES
COMMAND A TRANSFER MACHINE AND A CONVEYOR DEVICE TO OPERATE
IS THRE A LOT FININSHED UP ?
NO
YES
COMMAND A CONVEYOR DEVICE AND THE TRANSFER MACHINE TO OPERATE
CHECK IF WORKS HAVE PASSED THROUGH RESPECTIVE LINES FOR TREA-TMENTS
NOT YET
DONE
END
PREDICTION OF THE PROCEEDINGS OF JOBS (SIMULATION)
JOB INSTRUCTIONS

FIG. 9



SPECIFICATION
Manufacturing system

This invention relates to an automated manufacturing system of the type wherein, for manufacturing many kinds of products, there are provided groups of processors respectively corresponding to treatments each extending over several steps, and a conveyor system for carrying workpieces to be treated to the respective groups of processors, and the treatment sequence, treatment conditions etc. of the multifarious kinds of workpieces are automatically obtained from input information, to control the conveyor, the groups of processors etc. and to operate them efficiently and organically, whereby the product management and the process management are optimized. More particularly, it relates to a processing system for semiconductor wafers for manufacturing semiconductor devices in the semiconductor industry.

Circuit elements for use in assembling semiconductor devices, integrated circuits, large-scale integrated circuits etc. are, in general, formed of semiconductor pellets. The pellets are obtained in such a way that circuit element regions arranged and formed in a thin semiconductor plate (wafer) in vertical and horizontal arrays are split at the boundaries thereof. In order to fabricate the circuit element regions in the wafer, a very large number of manufacturing steps are required. By way of example, a process for forming regions containing desired impurity atoms in a silicon wafer includes (1) the washing step of washing the wafer to render it clean, (2) the oxide film formation step of heat-treating the wafer to form an oxide film (SiO_2) in the surface thereof, (3) the resist coating step of applying a resist (photoresist) onto the oxide film and then drying it, (4) the exposure step of causing a part of the resist to sense light, (5) the resist partial-removal (etching) step of partially removing the resist having sensed the light or not having sensed it, (6) the oxide film partial-removal (etching) step of removing the exposed oxide film by employing as a mask the resist partially remaining on the oxide film, (7) the resist removal (etching) step of removing the resist remaining on the oxide film, (8) the diffusion step of depositing the impurity atoms onto the exposed silicon or causing them to permeate the surface layer portion thereof by employing the oxide film as a mask and by situating the silicon wafer in an impurity atmosphere or utilizing such a technique as CVD (chemical vapor deposition), evaporation and ion implantation, and applying heat again to diffuse the impurity to a desired depth, and (9) the removal (etching) step of removing the unnecessary oxide film of the wafer surface, etc. The technique which begins with the resist coating step (3) and ends in the resist removal step (7) is usually called photolithography, which is repeatedly used for the formation of the circuit element. That is, it is employed for the formation of an interconnection layer, the formation of a protective film for passivation, etc. besides the impurity diffusion.

In addition, the course of the steps in the wafer processing in which the wafer is subjected to the various treatments as above stated differs depending upon the kind of the products because the different kinds of the products require differing contents of treatments. In this regard, if the so-called flow-shop-type arrangement is adopted in which equipment for different jobs is arranged in the order of the steps, the workpieces flow smoothly, but every kind of product needs to have an equipment arrangement peculiar thereto. Accordingly, when it is intended to mass-produce various products, stupendous installations are required, which eventually makes mass production impossible in practical use. Given that the equipment is disposed for the respective kinds of the products in order to permit such mass production, there is the risk that the arrangements of the equipment will soon become old-fashioned and useless because the development of semiconductor engineering is remarkable and the changes of products are radical. This leads to the disadvantage that the equipment investment is wasteful, so reduction of cost cannot be achieved. Therefore, the adoption of an expedient as illustrated in Figure 1 has been considered, forming a so-called job-shop-type arrangement in which groups of equipment for performing common jobs are collectively arranged. There are disposed a diffusion chamber 2 in which a plurality of diffusion devices 1 are arranged, an ion implantation chamber 4 in which a plurality of ion implantation devices 3 are arranged, a photoresist chamber 7 in which a plurality of photoetching devices 5 and exposure devices 6 are arranged, a CVD evaporation chamber 9 in which a plurality of evaporation devices 8 etc. are arranged, and a test chamber 11 in which a plurality of probes 10 are arranged. In the respective groups of installations, multifarious kinds of workpieces in large numbers are treated at once. Since, however, many kinds (several hundred kinds) of workpieces having different manufacturing methods (several tens of methods) are caused to flow in large numbers (several tens of thousand) at the same time in the wafer processings, it is difficult to skilfully manage the flow. In addition, long periods of time are taken until the products are finished. Another disadvantage is that many workers are required. The job space in which the wafers are treated needs to be always kept clean. Nevertheless, the large number of workers move round in the treatment chambers in such an arrangement, so that dust adhering to clothes and dust adhering to the floor etc. scatter by flying up and the wafers are stained to lower the percentage of satisfactory products. Especially, as the pattern of the circuit element becomes finer, the job space is required to be cleaner. In this regard, in the case where products having a very fine pattern are to be fabricated, the expedient as above described cannot possibly manufacture the products at a high percentage of satisfactory products.

On the other hand, human beings are essentially difficult to sustain in the most efficient state for long. In the aforecited manufacturing system, this is also a cause for prolonging the period of time for completing the products.

It has therefore been considered to make the wafer treating steps individually automatic, thereby to make the job in each step efficient and to enhance the percentage of satisfactory products by the maintenance of a clean job space.

It has also been considered to process the information of the management of the steps as they proceed by the use of a computer.

In these systems, however the automation of a single step is subjected to computer control, and the product management cannot be said to be satisfactory when viewed from the manufacturing course of a single kind of products. Moreover, since merely the individual steps are made automatic and the respective steps are independent themselves, the wafers must be carried by a worker between the automatic machines or the treatment spaces. This results in inevitably causing stains on the wafers between the respective steps. The existence of the worker in the moving path of the wafers is a fatal cause for staining them.

The present invention provides a manufacturing system comprising a plurality of treatment sections, each of which has at least one treating device that has a loading position and an unloading position and that automatically carries thereinto workpieces conveyed to said loading position, subjects the workpieces to a predetermined treatment and then carries them to said unloading position, and which subject said workpieces to respectively different treatments, a conveyance path which couples the respective treating devices, a conveyance device which moves along said conveyance path and which accommodates and holds said workpieces moving towards the loading positions and unloading positions of said respective treating devices, a transfer device which transfers said workpiece between said conveyance device and said loading positions and said unloading positions of said respective treating devices, and a control unit which controls said respective treating devices, said conveyance device and said transfer device.

Hereunder, embodiments of this invention will be described with reference to the drawings, wherein:

Figure 1 is a layout showing wafer processing chambers,

Figure 2 is a plan view showing an embodiment of a manufacturing system of this invention,

Figure 3 is a front view of a stocker in the embodiment shown in Figure 2,

Figure 4 is a side sectional view of the stocker in the embodiment,

Figure 5 is a front view showing the stocker and a conveyor in the embodiment,

Figure 6 is a front view showing the conveyor and a group of treating devices in the embodiment,

Figure 7 is a side view of the conveyor in the embodiment,

Figure 8 is a flow chart of the control process for the treatment steps in the embodiment, and

Figure 9 is a plan view showing another embodiment of this invention.

Figures 2 to 8 are diagrams for explaining a manufacturing system for semiconductor devices as is a preferred embodiment of this invention. Figure 2 shows a schematic plan view of a manufacturing system according to this invention, especially a wafer processing system. This wafer processing system occupies the entirety or a part of a building, in which many equipments are arranged. In the middle of the building, a conveyance path 12 is disposed in a manner to extend in the lengthwise direction of the building. The conveyance path 12 has many stop places (illustrated by marks O) 13. A plurality of treatment sections each consisting of a plurality of devices for treatments are disposed on both the sides of the conveyance path 12. More specifically, on one side of the conveyance path 12, there are respectively arrayed a CVD treatment section 15 consisting of two automated CVD (chemical vapor deposition) devices 14, a diffusion treatment section 17 consisting of four automated diffusion devices 16, a light-sensing treatment section (exposure treatment section) 19 consisting of four automated photoresist light-sensing devices 18, an etching treatment section 21 consisting of two automated photoetching devices 20, and an ion implantation treatment section 23 consisting of two automated ion implantation devices 22. On the other side of the conveyance path 12, there are disposed an evaporation treatment section 25 consisting of two automated evaporation devices 24, a test treatment section 27 consisting of three automated probers 26, and an automated stocker 28. At the rear of the stocker 28, there is disposed a central information processing chamber 30 which is a glassed chamber and in which a central control unit 29 having a computer etc. is disposed. By the side of the stocker 28 as well as the central information processing chamber 30, an air-conditioning and dust-removing machinery room 31 is provided. An apparatus, not shown, for cleaning the air is disposed in the air-conditioning and dust-removing machinery room 31, and the air within the whole building is cleaned by the apparatus. Regions A in the figure, that is, a region in which the conveyance path 12 is provided, a region in which the stocker 28 is provided, regions in which the various devices for treatments are provided and regions opposite the fronts of the various devices for treatments and the conveyance path 12 are kept at an especially high degree of air cleanliness (regions B form preservation rooms for repairing and adjusting the various treatment devices). In the figure, numerals 32 indicate doors.

Even where the same treatment is being applied, atmospheres for the treatment, for example, differ depending upon the process used, and the auto-doping of workpieces with harmful

impurities must be prevented. Therefore, the number of the treatment devices in each treatment section is increased. Also, in determining the number, the balance of the various devices is considered so that the flow of the works in the whole building may be smoothed.

At one end of each treatment device corresponding to the stop place in the conveyance path 12, a loading station (loading position) and an unloading station (unloading position) for carrying the work in and out are respectively disposed. The work supplied to the loading station is automatically carried into the processing portion of each treatment device and subjected to a predetermined treatment and is thereafter sent back to the unloading station as indicated by arrows in the two-dot chain lines. The stop portion 13 also faces the stocker 28.

On the other hand, conveyor devices (conveyors) 33 each holding and conveying a plurality of workpieces (in this case, a cartride receiving wafers, for example, a cartridge for transportation receiving 25 wafers in parallel) are disposed on the conveyance path 12. The conveyance devices 33 are disposed in the number of, for example, four, and they are individually controlled by the central control unit 29 to move on the conveyance path 12. At both the end parts of the conveyance path 12, there are provided conveyor device stand-by stations 34, in which the conveyor devices 33 not being operated stand by. The conveyor device 33 has wheels 36 under a pedestal 35 as shown in Figures 5 to 7, and is moved under radio control. A work receiving arm 38 extends sideways from a conveyor body 37 overlying the pedestal 35. It supports thereon the workpieces 39 carried out of the stocker 28 as shown in Figure 5, and shifts them to the loading station 40 of the treating device as shown in Figure 6. (In the unloading station, the workpieces are received. The transfer means may be a generally known device or mechanism, and is provided, for example, on the side of each treating device.) The work receiving arm 38 is also adapted to turn above the pedestal 35. In addition, the conveyor device 33 moves along the conveyance path 12 while detecting tapes which are stuck along the conveyance path 12 and which can be detected by optical, magnetic, mechanical or the like means. By way of example, it advances to a destination while counting the stop places 13 of the conveyance path 12.

As illustrated in Figures 3 and 4, the stocker 28 consists of a shelf 42 which has a plurality of accommodating portions 41 for accommodating the workpieces 39, and a transfer machine 43 which is free to move up or down and rightwards or leftwards in front of the shelf 42. Under the command of the central control unit 29, the transfer machine 43 takes out the workpieces 39 located at a predetermined position of the shelf 42 and supplies them to the conveyor device 33, or it holds the workpieces 39 carried by the conveyor device 33 and accommodates them into the empty accommodating portion 41 of the shelf. All the information of the workpieces 39 in the shelf are controlled by the central control unit 29.

Referring now to a flow chart in Figure 8, wafer processing operations will be described. First of all, all the workpieces (kinds of articles or lots to be treated — referred to as "works" in the flow chart) received in the stocker are confirmed (product management). When the kinds of articles (products) have been confirmed, treatments to be subsequently executed are known because process flows have been determined in advance. The present job states of the respective treating devices in each treatment section are confirmed, and the allowance and the finishing states thereof are examined. Further, the priority levels of the respective products (lots) are determined. These operations are executed on the basis of information stored in the central control unit. Thereafter, the presence or absence of an idle line (each treatment device) is checked, and whether or not there are workpieces (a lot) capable of using this line is checked. Further, whether or not the workpieces (lots) result in spoiling the priority levels is checked. If the priority levels are not spoilt, the conveyor device and the transfer machine are driven to make ready for carrying the works to a predetermined treatment device.

On the other hand, in parallel with the above operation, whether or not there is a lot finished up is checked. If such lot exists, the conveyor device and the transfer machine are driven to put the works into the empty accommodating portion 41. After all the lines have been checked, the treating devices, the conveyor devices and the transfer machine are operated while continually predicting the progress of the jobs.

The central control unit sometimes executes, not only the process management and product management of the workpieces (lots), but also the management of the process conditions of the various treating devices and the collection of the process data thereof and further the management of groups of sequence controls of the treating devices. When all the management operations are performed in the central control unit, the capacity of information storage, the quantity of calculations, etc. are large, and the size of the apparatus needs to be large. In order to avoid this drawback, it is also allowed that small-sized control units are contained also in the respective treating devices, the conveyor devices, the stocker etc. so as to divide the operations of storage, calculations, controls etc. among them and the central control unit. Over the central control unit, a control unit of larger size may well be situated.

The manufacturing system as above stated couples organically the automatic control of the devices and the automatic control of the process management, thereby to sharply reduce the number of workers who must be engaged in the manufacture. In order to establish both the versatility necessary for multi-kind treatments and the high efficiency necessary for large-quantity treatments, the arrangement of the respective treatment sections is made the job-shop-type, and

the construction of the treating devices themselves included in the treatment sections is made the flow-shop-type, to achieve consecutive automation. In order to make also the management of the process automated, the stocker in which unfinished products is put is situated in a specified place of the system such as the central part thereof, while the process is put forward in such a manner that the conveyor device controlled by the control unit having the computer reciprocates between the stocker and the groups of treatment sections.

Accordingly, the manufacturing system described brings forth the following effects:

(1) The so-called flow-shop-type wherein works are subjected to the same sorts of jobs by treatment devices in the same treatment section and wherein they are carried among various treatment sections by the use of a conveyor device is adopted and these operations are automatically managed by a control unit by taking also the product management and the process management into account. Therefore, the various treatment devices operate efficiently, and lots have their wafer processings completely successively from a desired lot, so that the job efficiency becomes high. Process conditions, a process monitor etc. are also controlled by the computer, so that stable treatments of high quality are made.

(2) Since this system is of the flow-shop-type which partly adopts the job-shop-type, the area of the building site can be made narrower than in the prior art.

(3) In principle, an operator does not enter the region in which wafers move. Since the operator who is the source of generation of a large quantity of dust, does not exist, the incidence of stains on the wafers decreases and the percentage of satisfactory products rises.

(4) Since the respective treating devices are repaired and adjusted from the rear, being the regions B in Figure 2, the space requiring a high degree of cleanness can be made smaller, and the air cleaner equipment can be made smaller in size than that in the prior art.

(5) Since all the jobs are rendered automatic in this system, the number of workers can be reduced.

This invention is not restricted to the foregoing embodiment. The number of treatment sections may well be still larger, and the number of treating devices in each treatment section may well be different from that in the embodiment. Although, in the embodiment, the conveyor device is adapted to move only within the building, it may well go directly into and out of an adjoining building in consideration with the couplings with other jobs. In the embodiment, the loading position and unloading position of each treating device are provided at an identical end, and the single transfer device is used in common. These loading and unloading positions, however, may well be separately arranged at the respective ends of the automated treatment device. The transfer device is provided with a mechanism for positioning the conveyor device and a mechanism for confirming the transfer of works. It is also possible for the conveyor device and the treating device, when positioned, to be docked so as to exchange information between the two devices. The transfer device may well be a roller conveyor system, a pusher system of the like. The conveyor device may well be controlled by a wired system. The conveyor device may well be other than the type which runs on the floor. It is also possible, as shown in Figure 9, for the stocker 28 to be arranged in the middle, around which the conveyor devices 33 are circulated so as to carry workpieces to respective treatment sections 44. In addition, this invention is applicable to techniques other than wafer processing.

As described above, the product management, the process management, the treatment conveyance management etc. are all executed by automatic control employing the computer etc., so that the respective treatment sections are organically controlled to smooth the flow of workpieces and to efficiently perform treatments successively from a desired lot. Therefore, reduction of the treatment cost can be achieved.

The job space and the preservation space are separated, and the former being a highly clean room can be made narrower than in the prior art. Therefore, miniaturisation of the air-conditioning and dust-removing equipment can be achieved, and the equipment cost can be lightened.

The operator does not enter the job space, and the processing conditions etc. of the respective treatment devices are properly controlled by the computer, so that very fine treatments can also be performed exactly and reliably and the percentage of satisfactory products enhanced.

The arrangement of the treating devices has the construction in which the job-shop-type and the flow-shop-type are coupled, so that the respective works can be caused to flow efficiently. In particular, according to this flow-shop-type, even a new series of products can be caused to flow as a line rationalized similarly to old products merely by adding data into the computer. Even when introducing new processes, they can be smoothly put into lines by handling them as groups of additional installations. Owing to the flow-shop-type arrangement, the necessary site can be narrowed.

CLAIMS

1. A manufacturing system comprising a plurality of treatment sections, each of which has at least one treating device that has a loading position and an unloading position and that automatically carries thereinto workpieces conveyed to said loading position, subjects the workpieces to a predetermined treatment and then carries them to said unloading position, and which subject said workpieces to respectively different treatments, a conveyance path which couples the respective treating devices, a conveyance device which moves along said

conveyance path and which accommodates and holds said workpieces moving towards the loading positions and unloading positions of said respective treating devices, a transfer device which transfers said workpieces between said conveyance device and said loading positions and said unloading positions of said respective treating devices, and a control unit which controls said respective treating devices, said conveyance device and said transfer device.

2. A manufacturing system according to claim 1, wherein said workpieces are moved among the respective treating devices by a cartridge which collectively accommodates a plurality of such workpieces.

3. A manufacturing system according to claim 1 or claim 2 having a central control unit which controls said control unit to perform product management.

4. A manufacturing system according to any one of the preceding claims having a stocker which has a plurality of accommodating portions that are arranged facing said conveyance path and that accommodate works therein and which transfers the works between it and said conveyance device, the stocker being controlled by said control unit which controls said respective treating devices, said conveyance device, and said transfer device.

5. A manufacturing system according to claim 4, wherein said stocker disposes of said works by means of a cartridge which collectively accommodates a plurality of such works.

6. A manufacturing system substantially as herein described with reference to Figs. 2 to 8 or Fig. 9 of the accompanying drawings.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1981. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.